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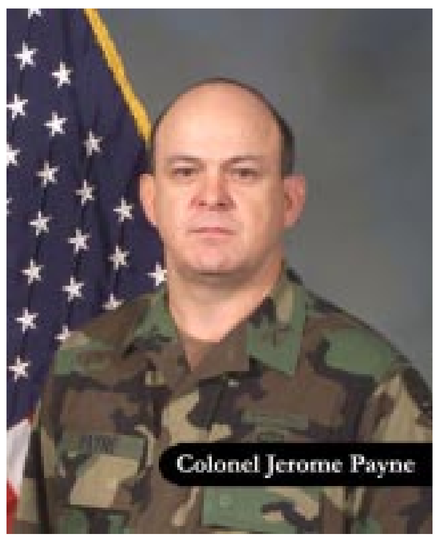
US ARMY ELECTRONIC PROVING GROUND
C4I Tester for the Army

Located in the high desert, 70 miles southeast of Tucson, Fort Huachuca is positioned in a valley with mountains in every direction. These mountains provide a relatively quiet electromagnetic environment suitable for command, control, communications, computer, intelligence, and electronic warfare (C4IEW) testing. In 1954 Fort Huachuca was selected as the site for the US Army Electronic Proving Ground (EPG).

Colonel Jerome Payne
Commander, US Army Electronic Proving Ground

The articles in this issue demonstrate the many components of testing which must evolve to ensure our success on the road to making "distributed testing" a reality. Success in this endeavor is dependant on the synergy which can be created by the seamless efficiency of software tools. These software tools must be fully integrated on multifunctional hardware, designed to capture data from a myriad of sources, and capable of moving this data through a network transparent to the operator. No single component is more important than another. Understanding that, the importance of synchronizing the development of these components cannot be understated!

With sufficient range space to provide realistic deployment and dispersion of a division slice of digital battlefield systems, EPG is uniquely capable of conducting robust system-of-system tests and those events required to stress large and small C4IEW systems. Leveraging the special strengths and talents of Fort Hood, Texas, and Fort Lewis, Washington, field offices enables an unparalleled capability benefiting both developmental testing (DT) and operational testing (OT). EPG actively supports the US Army Test and Evaluation Command philosophy of continued integration of DT and OT.



In his article, **Bob Reiner** (EPG's recently retired Technical Director) discusses EPG's transformation to a tester of networked systems-of-systems. He addresses the technology initiatives required to test Future Force Systems, Future Combat Systems, and related digital enablers. **Janet McDonald's** article describes the development of control, stimulation, simulation, and data acquisition and reduction software for network-centric testing as part of the Test Control Complex (TCC). The TCC is EPG's link to the Distributed Test Control Center's (DTCC's) network. **Alan Morris'** article entitled "EPG-Central Technical Support Facility Partnership in Distributed Testing," discusses how this important link gives us a portal to both the system integration laboratory environment and the warfighter. **Dave Kelso**, EPG's new Technical Director, provides an article, "Distributed Testing of Network-Centric Systems," discussing the challenges of network-centric testing and the importance of the DTCC in addressing them.

Ed Watt's article describes a successful distributed test applying digital technologies described in other articles.

Digitization is a reality and "distributed testing" is the vehicle needed to identify fully the limitations and capabilities created by inserting new systems into a fully integrated "system-of-systems" environment.

EPG will continue to build upon its 50-year legacy of exploiting new test and evaluation technology and applying it to the Army's ever-challenging communication-electronic mission. ⌘

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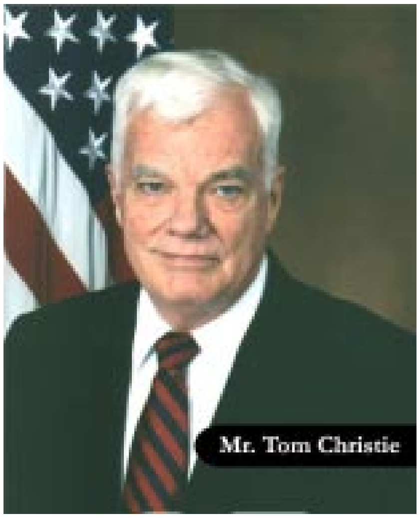
"WHO IS WHO" IN T&E


Mr. Tom Christie

Thomas P. Christie is the Director of Operational Test and Evaluation in the Department of Defense (DOD), a position he has held since July 2001. He is the senior policy adviser to the Secretary of Defense on testing of DOD weapon systems, establishing policy for operational test and evaluation, live-fire test and evaluation, and the composition and operation of the Major Range and Test Facility Base. Previous positions held by Mr. Christie are Director, Operational Evaluation Division at the Institute for Defense Analyses; Deputy Assistant Secretary of Defense for General Purpose Programs; and Director of the Air Force Weapon System Analysis Division at Eglin Air Force Base, Florida. Mr. Christie supports integration of developmental testing (DT) and operational testing where possible, but believes that some level of DT must verify system readiness for entering Initial Operational Test and Evaluation. He also advocates a greater tester role in experimentation and training.

Dave Kelso succeeds Reiner as New Test Director. After serving the US Army Electronic Proving Ground (EPG) for 26 years and the Army for more than 38 years, the EPG Technical Director, Mr. Robert (Bob) Reiner, retired on January 4, 2004. During his tenure with EPG, Bob was always at the forefront of technology, from lead engineer of the MAINSITE program, to key member of several Department of Defense Reliance Panels, to Technical Director. His immediate plans are to enjoy life with his wife Janet, spend time with his grandchildren, and pursue model railroading. Succeeding Bob as Technical Director is Mr. Dave Kelso. Dave brings to the position 25 years of experience testing Army and other Service Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance systems and systems-of-systems. His military background is as a signal officer in both the active and reserve forces of the US Army.

EPG Test Tools Support Training. (Extracted from an article by Ralph Liebert and Joseph Conklin describing their organization at Fort Lewis, Washington. It supports Mr. Christie's position on more tester involvement in training.) Although the primary role of the US Army Electronic Proving Ground (EPG) is that of developmental tester of communications and electronics, many of the tools that EPG has developed for testing have proven to be invaluable in support of training, both in garrison and in the field. They provide simulation and stimulation of command, control, communications, intelligence, and surveillance systems, and capture the data that flow across the battlefield. Their Mission Support Training Facility is the primary training asset for command staffs at Fort Lewis, Washington. EPG tools were effectively used to "flesh out" training and deployment issues for Stryker. Their Simulation Application Suite has been used by the 5th Corps, 18th Airborne Corps, and 25th Infantry Division Battle Simulation Centers to support stimulation of air defense command and control systems during training exercises.

Use of an Army Test and Evaluation Command (ATEC) Test Integration Network (ATIN) to transform testing. The Future Combat Systems (FCS) program will be a network-centric, multimission combat system extending across the entire scope of all Army weapon systems. Its testing will require management of data across all agencies. Each test organization within ATEC offers valuable test capabilities and expertise, but only a limited number of platforms will be available, and they may not be located at an ATEC location. The solution is ATIN. It will connect all of ATEC's test assets via DTCCs at each geographic location. These will operate in coordination with an Inter-Range Control Center (IRCC) that will serve as the command's network operations center. The IRCC will have the ability to link to the FCS System-of-Systems Integration Lab, the Joint Interoperability Test Command's Joint Distributed Engineering Plant, the Unit of Action Maneuver Battle Lab, and other points of presence as needed. ATIN utilizes the Defense Research and Engineering Network as a backbone for interrange and external communications. The goal is to immerse the limited FCS platforms in a virtual/live/constructive environment created by and accessible to all ATEC test assets. ⌘

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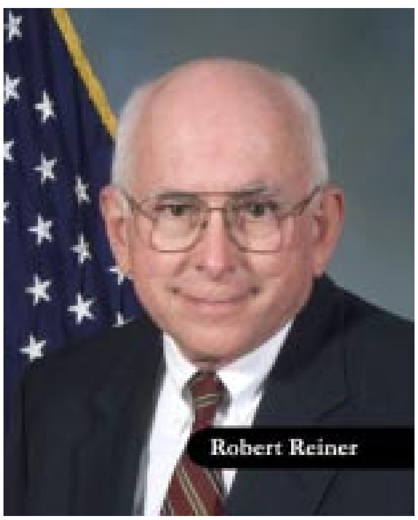
Evolving C4I Test Capabilities

Robert Reiner
Technical Director (Retired)
US Army
Electronic Proving Ground

Prior to his retirement as the US Army Electronic Proving Ground's (EPG's) Technical Director, Bob Reiner began blending the various components needed to transform his organization to meet the testing requirements of the Future Combat Systems. He discusses the software, hardware, facilities, and experience components required for innovative network testing.



EPG is a "customer focused" organization that leverages emerging technologies by focusing on adding value, quality, flexibility, and responsiveness in support of Department of Defense (DOD) Command, Control, Communications, Computer, Intelligence, Surveillance, and Reconnaissance (C4ISR) programs. The growth of the Army's system-of-systems (SOS) C4ISR architecture has led EPG to hone its test methodologies and instrumentation to support testing of these complex entities. The result of these efforts has made EPG the premier Government activity for the test of distributed communication systems with emphasis on the testing of SOS.

Our focus on SOS testing has led to the development of an organization well suited to test the existing C4ISR systems such as Force XXI Battlefield Command Brigade and Below, as well as the numerous new systems associated with the Army transformation and Future Combat Systems developments. As part of EPG's "transformation" to the new era of testing, we have embraced the digital world with development of an ensemble of hardware and software designed to collect and analyze systems with maximum efficiency while requiring only minimal numbers of support personnel.

"SOS" Focus at EPG

The SOS test methodology (shown in figure 1) embodies a well-defined process that uses simulation to design a test that integrates live, virtual, and constructive entities. These entities are stimulated with operationally realistic messages controlled by a master command and control capability which we call Starship. Under control of Starship, data are collected and reduced, and products are provided to our customers in their required format.

The Software Component. EPG develops SOS software to enable the conduct of testing in combined real, virtual, and constructive simulation environments. The software is developed under the Virtual Electronic Proving Ground (VEPG) project, a component of the Developmental Test Command's Virtual Proving Ground (VPG) initiative. The VEPG suite of PC-based software includes:

- **Starship Command and Control System**
- **Remote Reconfigurable Intelligent Instrumentation to Control, Collect, Simulate, and Stimulate (RICS)[2]**
- **ORION application for modeling radio communications effects**
- **Simulation Applications Suite – Interfaces Army simulations and tactical C4I systems**
- **Data Collection, Analysis, and Review Systems – Provides afteraction review capabilities to test/exercise customers**

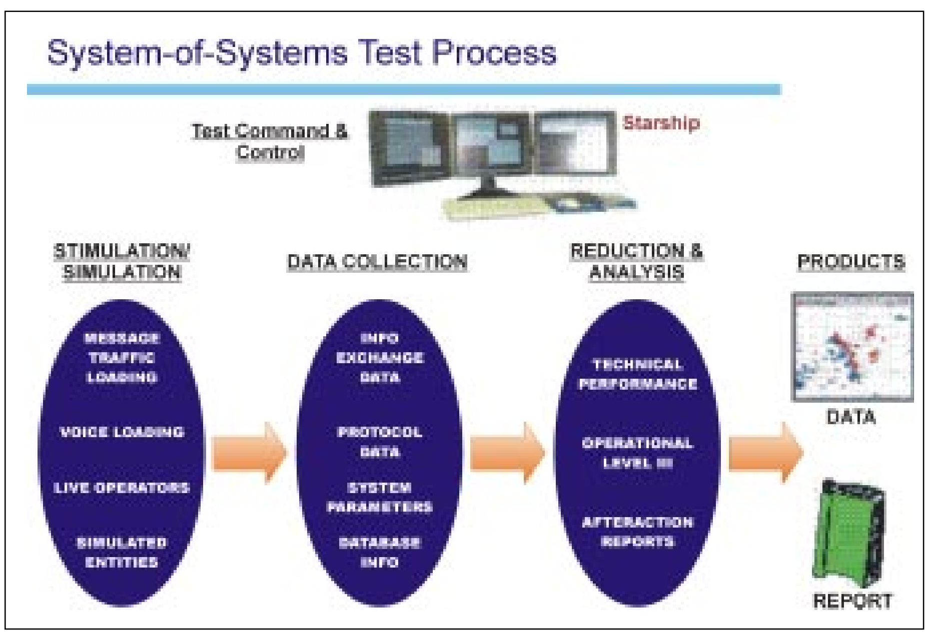


Figure 1. System-of-Systems Testing

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Evolving C4I Test Capabilities

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Details of each of these are in Janet McDonald's software article.

The Hardware Component. EPG's SOS hardware developments are collectively referred to as the C4I Test Toolkit. The toolkit includes a suite of instrumentation that enables fast and complete testing by providing realtime test control, test stimulation, test data acquisition, and virtual jamming. Specific equipment in the C4I toolkit include:

- **Modular Covert Remote Electronic Warfare Simulator**
- **GPS/Tactical Radio Enclosure**
- **Autonomous Wireless Sensor System**
- **Tenacious Timekeeper Position Plus-Peripheral Component Interface**
- **GPS Time on Video**
- **I-33 Jamming System**

C4I Tool Kit provides realism for SOS testing

EPG uses this instrumentation to provide realism to SOS testing with an absolute minimum of support personnel. To the operators of the equipment being tested, the tactical environment looks real; they are virtually integrated into a working live and constructive, simulated field environment. To make the test process complete, EPG operates the Army's flight test facility for unmanned/micro-aerial vehicles. The facility enables Global Positioning System testing, signal propagation simulation, C4I battlefield simulations, and the use of existing battle simulations in test and training activities.

The Facilities Component. Additional support to the testing of system components is provided by a full range of facilities, to include those that test for electromagnetic compatibility and vulnerability of tactical electronic equipment, the intra-/interoperability of tactical automated C4I systems (including software and documentation), information operations, Transient Electromagnetic Pulse Emanation Standard Testing (TEMPEST), and electronic countermeasure/electronic counter-countermeasures testing. EPG also has a full service C4I test bed that allows detailed testing of system components as well as support of realistic field testing.

Figure 2. Examples of recent systems

Facilities provide full-service test bed for system components

The EPG full-service electronic range using Starship, tracks and collects data from all types of air and ground systems. Our ancillary test capabilities provide a comprehensive suite of C4I testing and enable one-stop testing of networked systems, from tests of subsystems such as antennas, transceivers or switches to the test of complex SOS in a robust field environment.

The Experience Component. During the EPG's 50 years of test and evaluation experience, we have tested most of the major C4I and electronic warfare systems developed by the Army, and many systems developed by other DOD agencies. Involvement in SOS testing has been growing exponentially and has been the major focus of our activities over the last 10 years. In addition to testing onsite at Fort Huachaca, a significant portion of our non-radio frequency focused system-of-system testing has been conducted at other Army, DOD, and contractor facilities. Fort Hood, Texas; Fort Lewis, Washington; and the National Training Center, California, are prime examples of such tests. Examples of recent systems tests in which EPG has exported capabilities to support the warfighter are (see figure 2):

- **Force XXI Battle Command Brigade and Below**
- **Enhanced Position Location and Reporting System**
- **All Source Analysis System**
- **Single Channel Ground and Airborne Radio System**
- **Tactical Unmanned Aerial Vehicle**
- **Global Positioning System**
- **Maneuver Control System**
- **Millennium Challenge '02**

Through its focus on the key elements of transformation, EPG is postured to support the Army of the future. We look upon Army transformation and development of the Future Combat Systems as challenges and opportunities to excel. For further information, contact EPG's new Technical Director, Mr. Dave Kelso, at 520-538-8000, or email dave.kelso@epg.army.mil ⌘

State-of-the-Art Software Intensive Instrumentation for Distributed Testing

Janet McDonald
Chief, Data Engineering and Analysis
US Army
Electronic Proving Ground

The evolution of Command, Control, Communications, Computer, and Intelligence (C4I) capabilities at the US Army Electronic Proving Ground (EPG) is taking place in both the hardware and software domains. Ms. McDonald describes the most significant software development projects underway at EPG. These projects are building the necessary tools and infrastructure for command and control of the instrumentation to specify, collect, transmit, aggregate, store, archive, analyze, and access data while working in a live, virtual, or constructive environment. Some of the systems and "builds" are already in place and producing good results. Others are planned for the future to enable testing of the ever-expanding "system-of-systems" (SOS) battlefield networks.

Starship I. The centerpiece of EPG's C4I testing is a Personal Computer-based, Microsoft Windows software suite that enables the tester, developer, trainer, user, or integrated product team to plan, monitor, and control experimentation, training exercises, and test events. Called "Starship", the software suite provides near-realtime observation, orientation, decision, and action loops for equipment, applications, and simulated entities. Starship quickly alerts users if a monitored item is not functioning properly. The situational awareness (SA) Graphical User Interface can be easily tailored to display characteristics of interest for specific event requirements.

Mobile software suite supports tester-developer-trainer-user

Figure 1 illustrates Starship in support of distributed testing architectures. Starship assists in test infrastructure planning and graphic preparation of the event timeline, with scheduled commands to be issued at designated times. Graphic and text reports are produced by the program in realtime to assist in test execution and to support post-test assessments. An integrated suite of sophisticated C4I instrumentation, stimulators, and simulations can be remotely monitored and controlled by Starship's customizable user interface.

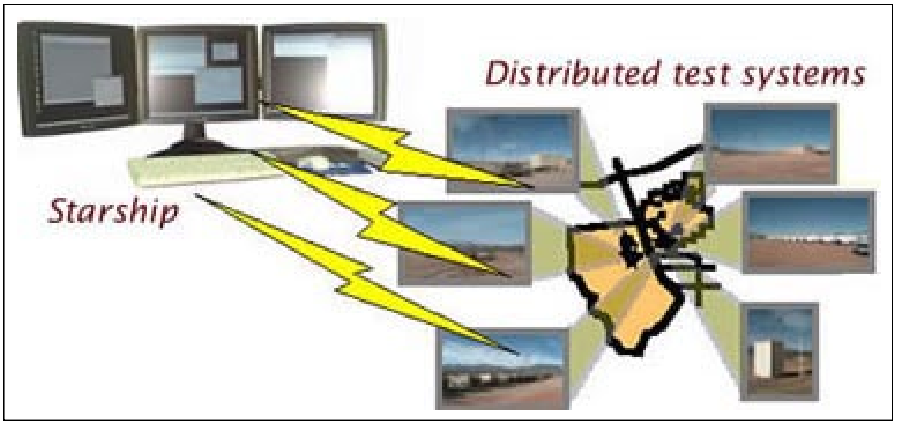

Figure 1. Starship Test Control

The suite is mobile and can support tests either onsite or interactively from a remote site connected by a communications link. It currently supports multiple communications media, including local area network (LAN), wide area network (WAN), radio, secured radio, encrypted LAN, the Defense Research and Engineering Network, and is adaptable to DOD protocols such as Testing and Training ENabling Architecture (TENA), Distributed Interactive Simulation (DIS) and High Level Architecture (HLA). Starship can remotely monitor and control test instrumentation and other devices such as:

- **Remote Reconfigurable Intelligent Instrumentation to Control, Collect, Simulate and Stimulate (RICS)[2]**
- **Modular Covert Remote Electronic Warfare Simulator**
- **Ground Track-Vehicle Tracker**
- **Improved Function Data Collector**
- **Radar Instruments**
- **Precision Lightweight GPS Receiver devices**
- **Advanced Distributed Modular Acquistion Systems**

Starship II. The next generation software, identified as Starship II, will build on the functionality provided by its predecessor and will maintain the industry-standard "n-tier" architecture, object-oriented design, components, and extensible markup language technology in Starship I.

Starship II has been launched and is "underway"

By employing a distributed network of Starship II instances, configured in a peer-to-peer or hierarchical organizational structure, the new software expands the situational awareness track-and-display capability from hundreds of entities to tens of thousands of entities. It will be capable of controlling real and simulated test instrumentation (either current or new), have multiple information displays for more than one client, and provide autonomous agent-enabled instrumentation and automation of any partial or complete test processes. Additional C4ISR Toolkit software suites are described in the following paragraphs.

Remote Reconfigurable Intelligent Instrumentation to Control, Collect, Simulate and Stimulate (RICS)[2]. This versatile system with a long name executes tasks, directed by Starship, such as collection of data, stimulation and

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State-of-the-Art Software Intensive Instrumentation for Distributed Testing

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simulation of real traffic, and control of test network loading. It sends and receives C4I data in support of large experiments (Millennium Challenge 02, Roving Sands), tests of tactical radios (Joint Tactical Radio System), and training exercises.

RICS^2 sends and receives ground truth data for training and testing of C4I systems, tactical radios, & LAN/WAN networks

The suite uses commercial-off-the-shelf software and hardware with internal Global Positioning System (GPS) and data radios to provide time tagging and remote control and monitoring of RICS^2. Some key functions include physical interface to tactical radios, traffic generation for unformatted free text stimulation, Joint Variable Message Format stimulation, Interface Network Controller, high-speed LAN and WAN data collection, and bandwidth monitor for network monitoring. We are continuing to enhance the instrumentation suite to support:

- **Advanced waveform radio stimulation and data collection**
- **Increased WAN traffic stimulation and data collection**
- **Increased data volumes resulting from continuous SA in Future Combat Systems (FCS)**
- **High-speed voice/data/video nodes**
- **Adaptable/flexible/seamless networks**
- **Autonomous agents or intelligent instrumentation**
- **Embedded instrumentation**

Orion/Electromagnetic Engineering Workshop. This is the software model of radio communication effects in a dynamic "mission space" of mixed live and simulated entities. It is used for test planning and distributed simulation and testing. Orion is used to perform dynamic radio frequency communications link analysis and transmitter area coverage plots. A radio network model was recently added to support Virtual Proving Ground Synthetic Environment Integrated Testbed demonstrations. Future enhancements to Orion will include spectrum and interference modeling, foliage models, noise and bit error rate models, GPS and satellite modeling, and improved network models to support FCS.

Simulation Application Suite (SAS). The suite provides a synthetic testing environment interface between simulations and the real-world tactical C4I systems by automating the most common actions, orders, and reports. SAS replicates the battlefield operational stresses placed on a C4I system, providing the information flow from an entire division or corps echelon, with relatively few soldiers and at minimum cost. The next generation of SAS will provide a tactical C4ISR environment for a flexible/scalable/seamless networked SOS. It will determine and apply appropriate battlefield stimulation requirements for a wireless, networked, on-the-move SOS. Next generation SAS will incorporate new Future Force/Future Combat System (FF/FCS) message formats, threads, and battlefield scenarios. It will interface with current and future simulations to support FF/FCS testing and support the Tactical Digital Information Links message format.

Data Collection, Analysis, and Review System (DCARS). Figure 2 illustrates this combination of a data collection system with an afteraction review system for both operational and technical test data collection and analysis. Future DCARS will run on a "Windows platform," have 3D graphical plotting and animated live plotting and replay, stand-alone plotting and analysis with remote analyst workstations, and statistical analysis products based on message and data collection metrics.

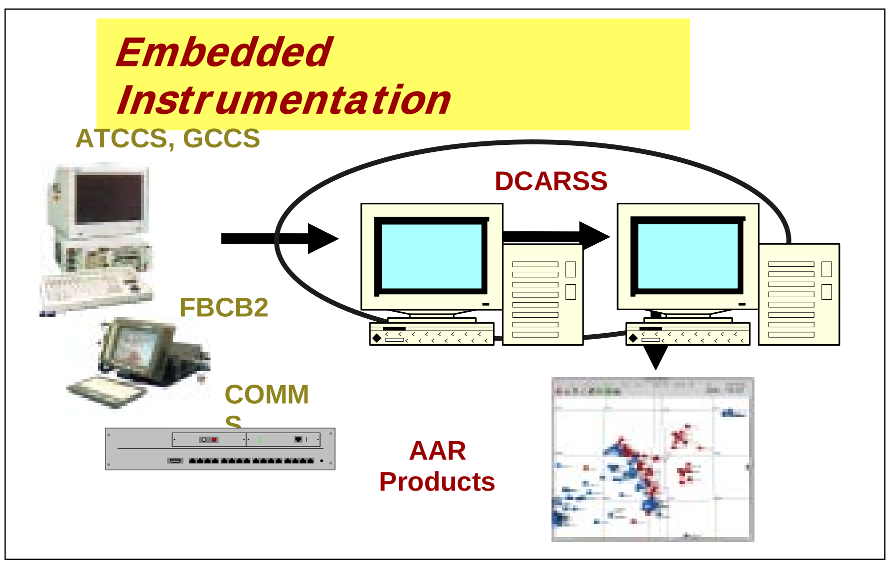

Figure 2. DCARS

Communications Mission Support Planner (CMSP)— More spectrum-dependent equipment in the military means a greater number of frequencies to support such equipment.

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State-of-the-Art Software Intensive Instrumentation for Distributed Testing

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To conduct the C4I SOS tests envisioned for the Future Force, much spectrum planning will need to be performed before testing begins. The CMSP will enable test officers and spectrum managers to determine their spectrum requirements for those tests. Although spectrum managers have tools with which to process frequency requests, an automation gap exists between individual units that have frequency requirements and the higher echelon spectrum managers who have tools such as SPECTRUM XXI and the Joint Automated Communications-Electronics Operating Instruction System (JACS) with which to process requests. CMSP is an automated tool that will fill this gap.

CMSP allows the test officer to identify frequency-dependent equipment, using easy to understand formatted screens. It then builds requests for frequency support in a Standard Frequency Action Format that can be imported directly into Orion, SPECTRUM XXI, and/or JACS for further processing. CMSP will streamline today's labor intensive process of gathering this information by the spectrum manager or the test officer.

Figure 3. EPG is linked to ATEC's VISION system

The EPG Data Repository. Currently in development, a centralized repository of all EPG test information will support all EPG software development and testing. It will enable testers and customer users to easily locate information. The repository will archive and track tests, provide a workflow process, and maintain version control. The EPG repository is the first step for entering data into the DTC Versatile Information Systems Integrated, ONline (VISION) system, (Figure 3) and ensuring that data are correctly entered into the Integration Level Hierarchy catalog.

Communication Mission Support Planner provides easy to understand screens for test officers

Summary. EPG has been conducting distributed C4I "systems-of-systems" tests for 15 years. During that time we have acquired the tools, experience, and knowledge to perform testing in a mobile, networked SOS environment. The tools discussed in this article are specific examples of our work. Our approach is to enhance proven capabilities uniquely suited to test concepts, development, and networked joint events, while continuing to explore the emerging new technology and capabilities that will enhance our future Army.

For additional information on this subject, contact Janet McDonald at 520-538-4958 or email at janet.mcdonald@epg.army.mil. ⌘

EPG-CTSF Partnership in Distributed Testing

Alan Morris
Test Engineer
US Army
Electronic Proving Ground

Distributed testing and cooperative partnering have become very important parts of the US Army Electronic Proving Ground (EPG) mission. The Central Technical Support Facility (CTSF) at Fort Hood, Texas, is a system integration lab whose mission is to integrate and certify Command, Control, Communications, Computer, and Intelligence (C4I) software. The CTSF is an intermediate staging base for Command and Control (C2) software fielded to units engaged in Operation Iraqi Freedom (OIF) and EPG is an integral part of the CTSF operation. EPG provides test expertise, in-house-developed instrumentation, and a distributed test approach linking the CTSF with Fort Huachuca and other remote sites to leverage the strengths of all for more realistic and cost effective data collection events.

A Cooperative Environment. The CTSF integrates and certifies the software required to digitize and transform the way our forces fight. This transformation requires rapid development, fielding, and support of leading edge, survivable, secure, and interoperable tactical, theater, and strategic command, control, and communication systems. The CTSF at Fort Hood is staffed by over 600 Government, military, and contractor personnel. The contractors represent 35 system development companies. This collection of talent at one location enables the developer, tester, and user to work together to expedite the process of providing the latest technology in C4I systems to our Soldiers in the field. The effectiveness of this cooperative effort was recognized by Brigadier General Mike Mazzucchi, Program Executive Officer, Command, Control, and Communications (Tactical), in a statement on February 18, 2003:

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EPG-CTSF Partnership in Distributed Testing

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"…It is the synergy of being collocated that speeds cycle time and allows for near realtime solution finding and problem fixing. I'm also very encouraged by your increasing capability to work issues 'virtually' via teleconference, file transfer protocol, and automated updates. You are not only challenging the way we'll fight and sustain, but the way we even think about it."

The CTSF provides system-of-system integration testing, configuration management, and field engineering to digitized Army Battle Command Systems (ABCS) 6.X and BCS warfighting units. Also, the CTSF continues to perform command and control validation and interoperability certification of software and systems in support of OIF. EPG personnel provide expertise and instrumentation to accomplish this mission. Support comes from two branches: the Systems Engineering Branch and the Test Cell Branch.

Systems Engineering (SE) Branch. EPG provides several Government engineers in support of the SE Branch within the CTSF. This branch provides engineering oversight to both the software development and the network installation and maintenance efforts. SE also provides pretest checks of software loads, patches, and database drops prior to formal testing. Additionally, SE conducts specific technical investigations which often result in fixes and patches to correct software functionality or to deliver new functionality to formal testing.

The SE Branch deployed an EPG engineer in support of Operation Enduring Freedom to survey digital capability of deployed tactical units (See figure 1). From this survey, the CTSF dedicated an entire test floor to the test-fix of software in an architecture respresentative of theater operations.

Test Cell Branch. EPG provides the testing skills for the CTSF. This branch is made up almost entirely of EPG personnel. One Government civilian and 51 contractor personnel represent 93 percent of the Test Cell Branch. EPG also augments with instrumentation support, providing nine additional personnel. In a digitized world, it is imperative that the evaluator have the necessary tools to analyze software and hardware effectively in an architecture that is representative of the tactical environment. EPG has the ability and experience to

Figure 1. CTSF Certifies Interoperability Software for Operations Iraqi Freedom and Enduring Freedom

conduct a distributed test utilizing the architecture in the CTSF lab in conjunction with remote architecture pieces linked together with the Defense Research Engineering Network. This combines certification done in the lab with developmental testing in the field, allowing the evaluators to leverage data collected in a lab and field environment and assess hardware/software performance in a more robust and realistic manner. Distributed testing can be done in parallel with CTSF certification at a reduced cost. Using the US Army Test and Evaluation Command's (ATEC's) Inter-Range Control Center, a mix of live, virtual, and constructive elements can be tied into a controlled electromagnetic environment at Fort Huachuca, thus bringing realistic radio frequency communications into the test exercise. EPG provides the instrumentation and operating personnel to support this requirement.

Distributed Testing. The CTSF can act as a virtual extension to tests conducted at EPG Fort Huachuca through the Test Control Complex (TCC). For system-of-systems testing involving more than Command, Control, Communications, Computer, Intelligence, Surveillance, and Reconnaissance programs, the TCC, in its role as the Fort Huachuca Distributed Test Control Center, will support connection to other test centers across the ATEC distributed test network.

Summary. An important adjunct to EPG's electronic systems testing mission is the support of tests outside the geographic bounds of Fort Huachuca, Arizona. A prime example is the cooperative work with the CTSF activity at Fort Hood, Texas. The CTSF mission is to test, integrate, and certify the ABCS and numerous other Army and Joint C4I systems.

EPG's C2 Protect and Blue Force Tracking tests prove that it can be done.

Moreover, the resultant capability is greater than either organization is capable of producing alone. EPG, in its partnership with CTSF, has taken some of the first steps for ATEC in the realm of distributed and cooperative testing. They will not be the last!

For further information, contact Alan Morris, telephone 520-533-8275; email: alan.morris@epg.army.mil ⌘

Distributed Testing of Network-Centric Systems

EPG's Evolutionary Testing Approach

David H. Kelso
Technical Director
US Army
Electronic Proving Ground

Information dominance is critical to the success of current and future military operations. As the concept of situational awareness evolves into situational understanding, the digital Army is quickly becoming a reality. Network-centric operations demand network- centric testing to support evaluation. This article describes how EPG has become involved in network-centric testing today as well as our vision for the future using EPG's Test Control Complex and the US Army Test and Evaluation Command (ATEC) Inter-Range Control Center.

EPG's Path to Network-Centric Testing. Historically, EPG has concentrated on testing complex communications and navigation systems, such as Global Positioning System, Enhanced Position Location Reporting System, Single Channel Ground and Airborne Radio System, and Mobile Subscriber Equipment, as "systems." These systems stood out from the other systems of their time due to their reliance on software, their nonlinear responses to external stimuli, and their ability to handle significantly higher data and information rates. As such, these systems were among the first to be tested with EPG-developed stimulators and simulators. During the late 1980's and early 1990's, EPG concentrated on testing systems connected by networks such as Army Tactical Command and Control System (ATCCS). These tests required the integration and interoperability of multiple complex systems into a single command and control super system. Although much more complex than the tests of single communication and navigation systems, the tests did not begin to touch upon the added complexities of network-centric systems since the communication system was not considered part of the test. During these tests, data were collected simultaneously from multiple distributed geographic locations and then aggregated into a single data package for analysis. These limitations were resolved with EPG's Test Control Center and the suite of automated data collection instrumentation which has evolved over time into our Command, Control, Communications, Computers, and Intelligence (C4I) Test Tool Kit. It was not until the mid 90's that EPG started to become involved in network-centric tests.

When the Army's initial experiments with digitization began, the assumption was that existing Government-furnished communications equipment could be reconfigured into new configurations and groupings on new or existing platforms, without impact on performance. This was quickly disproved. With the addition of closely located transmitters and increased transmission duty cycles, mutual interference, communications fratricide, or self-jamming occurred.

First tests of a network-centric "system-of-system" conducted at EPG in 1996

To prevent these and other unexpected problems from slowing the Army's march toward digitization, the first of many Army field tests of a network-centric system-of-system was conducted at EPG in 1996.

This first test involved the tactical Internet and Force XXI Battle Command Brigade and Below (FBCB2), illustrated in figure 1, page 10 . Later, as technology and doctrine evolved, field tests included ATCCS and an organizational slice of an entire division. The purpose of these field tests was to address the impact of stochastic bandwidth limitations caused by propagation and tactical communication systems on commercial and military software that had been integrated in the lab to ensure interoperability. The problems of data base population and system-of-systems stimulation through a tactical network of networks were solved for this challenge using the Simulation, Test Operations and Rehearsal Model (STORM) and then later the Command, Control, and Communications (C3) Driver.

Hybrid Network-Centric/ Layered Testing. Today, most EPG tests are network-centric in some manner. Tests can no longer be categorized as platform, system, network, or system-of-systems; rather, they are hybrids, each with aspects of all categories. We now test in layers - the platform (also tent, soldier, or building), the network (communications, protocols, routing and terminal equipment compatibility), and the information (databases, information compatibility).

Platform layer or single platform system tests conducted today determine if the platform and its integrated systems can successfully operate within the network-centric architecture of the current digital Army. Testing is conducted in the field for performance and in the chamber for characterization of areas such as electromagnetic interference and electromagnetic compatibility. Platform layer testing determines if the platform can operate and communicate, including operation under expected load and electronic stress. For these tests, databases are populated, systems are stimulated with realistic traffic, and responses to those stimuli are observed using the C4I Test Tool Kit. This platform layer testing does not determine the impact on the network-centric environment, the performance of the network or information layer, nor the ability of other platforms to successfully complete mission threads.

Network layer or communication system tests are conducted to determine performance characteristics such as bandwidth limitations, range, electronic and information vulnerabilities, self-healing, internal network situational awareness, and others. Tests may involve the performance of a single network (e.g., Joint Tactical Radio System), the integration of multiple networks into a single network (Tactical Internet), or the ability of a platform-level entity to

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successfully perform over one or more networks (e.g., FBCB2). For these types of tests, databases are populated, the network is stimulated from multiple points with realistic and "background filler" traffic, terminal equipment is emulated, data are collected at multiple locations simultaneously and then aggregated. "Realtime" test situational awareness is required for adequate understanding of the test and data to permit an accurate analysis and interpretation of the data for the decisionmaker. These tests involve representative field elements (buildings, commercial vehicles, sheds, etc.), and are distributed over representative tactical distances. Some elements may be conducted in the lab and connected to elements in the field. Usually, these tests are conducted on a single military installation but may be distributed over several installations. Situational awareness and understanding are provided to the EPG test director via the Test Control Complex.

Information layer tests are commonly called integration, interoperability, or system-of-system tests. They involve multiple platform level systems interconnected at the network level to determine performance issues, such as information compatibility among systems and databases, and if the common operational picture is interpreted correctly from tactical ground truth into a single common relevant operational picture. During these tests, tactically relevant and operator usable stimulation (messages and information) is produced by tactical operational simulations external to the test, such as C3 driver or STORM, and enters the network at multiple points. Data are collected simultaneously over multiple locations and then aggregated using elements of the C4I test tool kit to determine information transfer metrics and causality of anomalies. Critical data elements used to identify test validity are displayed in near realtime at the Test Control Complex. This permits the test director, customer, and evaluator to redirect resources to ensure all required data are collected to answer the needs of decisionmakers. In addition, the Digital Collection, Analysis, and Review System (DCARS) component of the tool kit is used to determine the sensor information (message and database), display, and user perception of reality. These tests can be conducted in the lab and in the field simultaneously at single and multiple geographic locations.

Intensive Network-Centric Testing – The Next Level. Unlike today's platform level entities, which share information only as a result of deliberate communication between independent databases, the Future Combat System and others that will follow will have single and multiple common databases distributed across multiple platforms. Instead of communicating database updates among redundant and independent databases, information will be automatically pushed and pulled between elements of a single database(s) to satisfy Soldier and machine anticipated demands. As a result, it will no longer suffice to merely stimulate the elements of the network-centric entities of the future. Instead, the elements under test will need to be immersed into a tactically relevant network-centric environment that includes information traffic load as well as the database and information elements found outside the elements under test. This will ensure that elements under test have the necessary information to accomplish their assigned missions successfully, and push and pull it as required to/from other sources. Although the platform level test may be conducted in either the laboratory or the field, the encapsulation may come from multiple sources which may include one or more multiple simulations, other platform level tests, or even network and information level tests conducted at other locations simultaneously. Network level testing requires stressing the network at realistic tactical levels. It must be encapsulated by the network-centric environment of the future, but the encapsulation will be perceived from a different perspective. In order to successfully self-heal, the network of the future will need to monitor individual nodal and user demands as well as the network environment. The encapsulation for the network must generate realistic traffic. The information push-pull demands as well must provide shared information (external to the elements under test) to permit the network to adequately self-heal and anticipate user demands. This must be accomplished with corrupted and noncorrupted information, under a variety of scenarios such as electronic, information, and physical warfare losses. In order to do this, the "intelligent" aspect of the network must be able to communicate with the encapsulation and push/pull information from "users" and nodes external to the "physical test" in order to understand its environment. Although early network level tests will be conducted in the laboratory and then move to the field, the encapsulation for the network level tests will likely come from multiple sources such as one or more multiple simulations, ongoing platform level tests, and even network and information level tests conducted at other locations simultaneously. As is the case today, the information level tests of the future will be the most complex. Unlike the network or platform layer tests where an organizational slice may work, all entities which generate the relevant

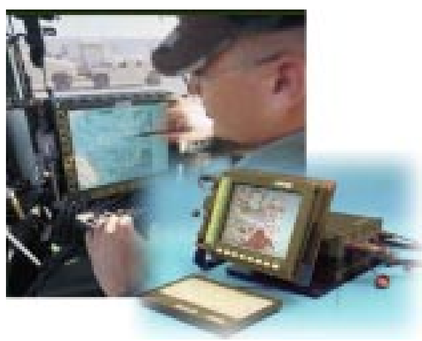

Figure 1. FBCB2, Tactical Internet

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network-centric information environment will be required (as virtual or physical players) to test the information layer. Since the information will be distributed among numerous physical entities and across multiple platforms at different geographic locations, the information layer of the future will have additional test challenges. Comparing the machine perception of reality to tactical ground truth as it is displayed and used by the user will remain a requirement.

Critical to the success of these future "system" tests will be the Distributed Test Control Center (DTCC). EPG's test control complex, in its role as the node for the C4ISR portion of distributed weapon systems, will permit sophisticated distributed testing to occur on a global scale, and permit DTC to virtually extend and leverage the strengths and capabilities of multiple test centers. The Test Control Complex and the DTCC will take its test centers to the system under test rather than the reverse, which happens today.

Conclusion. EPG will continue to provide risk mitigation information to Army and Department of Defense decisionmakers. To accomplish network-centric testing of the future, EPG, its tools, and test control complex (DTCC for C4ISR) will evolve along with the systems we test. Our technology will evolve to include the capability to encapsulate the network-centric systems of the future. Electronic encapsulation will enable the other test centers within DTC to test the non-C4ISR network-centric aspect of these new and innovative weapon systems of the future. Our organization will evolve to better support DTC technologies. Fast-moving technology will create many challenges for EPG, and we look forward to attacking these challenges with vigor as part of Team DTC.

For additional information, contact Dave Kelso at 505-538-8000 or email: dave.kelso@epg.army.mil. ⌘

Successful Distributed Test Earns DOT&E Kudos

IOT&E of Force XXI Battle Command Brigade and Below Links DT&OT Sites

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A combination Developmental Test/Operational Test (DT/OT) event conducted early this year was a prime example of ATEC's growing distributed testing capability. Live and simulated entities across the country were tied together with participants at the US Army Electronic Proving Ground (EPG), Fort Huachuca, Arizona; the Central Technical Support Facility (CTSF), Fort Hood, Texas; and Fort Bragg, North Carolina.

Figure 1. Stryker

In support of the third and final phase of a recent Initial Operational Test, 50 live communication nodes (CNs) at Fort Huachuca, 33 live CNs and 1200 simulated CNs at Fort Hood, and live helicopters located at Fort Bragg were all seamlessly tied together using the DREN. This architecture incorporated segments of the 3rd and 4th Infantry Divisions, 1st Cavalry Division, Stryker Brigade Combat Team-1, and 1st Armored Division. The Stryker is illustrated in Figure 1.

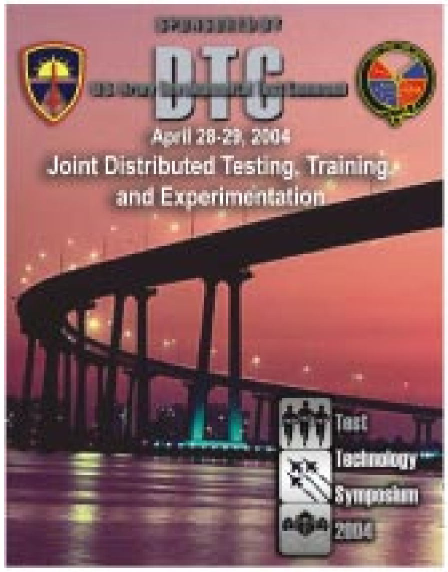
With realtime control provided by EPG's Starship, and same day data extraction, reduction and quick-look capabilities, the test successfully provided data to the PM, AEC, DTC, and OTC enabling system assessment. Mr. Tom Christie, OSD's Director of Operational Test & Evaluation, expressed kudos for the planning, execution, and reporting of the test event and its contribution to the independent evaluation.

For additional information, contact Edward Watt at 520-533-8133 or email ed.watt@epg.army.mil. ⌘

High Marks for Test Technology Symposium (TTS) 2004

The US Army Developmental Test Command hosted its annual symposium in San Diego, during the week of April 27-29. This year's program expanded upon last year's very successful symposium adding the dimensions of distributed experimentation and distributed training, and also the opportunities for testing as a joint force. DOD, Army, Navy, Air Force, and Joint Forces Command presentations supported an excellent program. The TTS event was preceded by Industry Day briefings during which ATEC agencies discussed needs and opportunities for contract support.

The west coast site proved to be a good choice based upon the growing Department of Defense (DOD) emphasis on joint experimentation, testing, and training and the fact that several key Army, Navy, and Air Force agencies involved in distributed testing are located in the west. The program received "high marks" enabling conferees from across DOD to reinforce testing partnerships. The sharing of technologies promoted experimentation, testing, and training under the most realistic battlefield conditions; i.e., as a joint force. A wealth of information was disseminated to those planning for tests of the networked systems-of-systems (e.g., Future Combat System) now in development.



Mr. Walter Hollis, the Army's Deputy Under Secretary for Operations Research, delivered the keynote address to the 315 attendees, the second largest audience ever for this event. BG Keith McNamara (then - DTC Commander) was joined on the podium by Navy Rear Admirals Michael Sharp (Space and Naval Warfare Systems Command) and David Venlet (Commander, NAVAIR Weapons Division, China Lake) in promoting the need for closer ties among testers and evaluators. Other feature presenters and field operators/testers described the distributed testing process and lessons learned through experiments and joint tests conducted to date. The symposium was "capped off" by a joint Service executive panel which responded to questions from attendees. On the morning of April 30, about 100 of the attendees were treated to a tour of the nuclear aircraft carrier USS Nimitz, currently being readied for its next assignment.

The presentations have been posted electronically at the DTC Web site http://www.dtc.army.mil/tts/2004/tts04pr.html. ⌘

FOR THE COMMANDER:

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